Helios Mission Support

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Data from both Helios-1 and Helios-2 spacecraft in solar orbits continue to expand man's knowledge of our solar system. Having completed their third and first aphelions, respectively, the trajectories of both spacecraft will bring about perihelions in October 1976. Helios 2, while still in its five-month (May–September) superior conjunction, continues to supply valuable data for experiments 11 and 12 (Celestial Mechanics and Faraday Rotation). Helios 1 remains in cruise phase.

I. Introduction

This is the eleventh article in a series that discusses Helios-1 and -2 mission support. The previous article (Ref. 1) reported on Helios-1 and -2 cruise, radial and spiral alignments, Helios 2's entry into first superior conjunction, Spaceflight Tracking and Data Network (STDN) cross support, and DSN-STDN engineering tests. Also included were actual tracking coverage and DSN system performance. This article covers a Helios-1 spacecraft power anomaly, Helios-2 occultation, final DSN-STDN engineering test results, tracking coverage, and DSN performance for June and July 1976.

II. Mission Operations and Status

A. Helios-1 Operations

Approaching its third aphelion, the Helios-1 spacecraft was functioning normally (high power, high-gain antenna, power regulator 1, ranging-off) except for the spacecraft ranging temperature problem (Ref. 2). Comparisons between Helios-1 and -2 data were made as the spacecraft passed through spiral and radial alignments.

While DSS 44 (Australia) was tracking the Helios-1 spacecraft on pass 561 (21 June 1976), the downlink signal began to degrade. Within one-half hour the receivers could no longer maintain carrier lock. Following routine verification of proper station configuration and reporting to project personnel, short-term use of DSS 42 (Australia) was negotiated with the Viking Project. After reconfiguring for Helios 1, DSS 42 performed a spacecraft search; no signal was detected, thus verifying DSS 44 operations. Meanwhile telemetry data analysis at JPL revealed that the plus 26-volt power value in the telemetry data had changed from 26.98 volts (nominal) to 23.56 volts prior to loss of signal. About one hour later the 100-meter antenna at Effelsberg (DSS 67) was activated, but no downlink carrier could be detected. After careful analysis of the anomaly, the spaceflight team reasoned that the high-gain antenna (HGA) pointing was incorrect. A command was sent to switch to the medium-gain antenna (MGA). After this, the German Effelsberg 100-meter station acquired a downlink signal. Spacecraft status showed that all instruments had been switched off; power regulator 2 was switched on; the spacecraft data handling system had gone to the "safe mode," and the HGA was pointing directly away from Earth. The spacecraft had apparently suffered a power overload (at 206 watts) and shut itself off (safe mode).

The next few days were spent in experiment turn-on and checkout, and reconfiguring the spacecraft as close as possible to the previous status while limiting total power consumption to 200 watts.

Present spacecraft status has all experiments back to normal, transmitting on the HGA at high power and high carrier suppression. The spacecraft is in cruise, having passed its third aphelion.

B. Helios-2 Operations

Still in superior conjunction, Helios 2 is following Helios 1 through aphelion. Plans were made to collect special data during this mission phase. Calibration procedures and data requirements for the 1 July to 5 October 1976 period were distributed to the Network. These data are being collected and preliminary analysis is presently underway.

Helios 2 experienced its second blackout (Sun–Earth–probe (SEP) angle ≤ 1 degree) from 3 through 17 July 1976 (the first blackout occurred on 16–17 May 1976). During this blackout, all communication with the spacecraft was lost – no station could maintain lock on the spacecraft carrier. A blackout timer onboard the spacecraft was set, causing the data to be stored. The memory contents will be read out as soon as higher data rates (64 b/s) are possible. With the spacecraft's trajectory keeping the Sun–Earth–probe angle less than 5 degrees from May through September, higher telemetry data rates are not expected until late August when the SEP angle is between 4–5 degrees.

The first aphelion was reached on Julian Day 200 (18 July) 1976 at 2200 GMT. All spacecraft experiments were functioning normally as the first orbit was completed.

Present spacecraft status indicates all experiments normal, transmitting on the HGA at high power and cruising toward its third blackout (approximately 25 September).

C. DSN-STDN Engineering Tests

The DSN engineering tests regarding STDN real-time telemetry and command cross-support for Helios (Ref. 1) were successfully completed during the month of June. The concept of utilizing interstation microwave links to send Helios modulated subcarriers (both telemetry and command) between the STDN receiver–transmitter and a DSN telemetry–command data processing computer string was demonstrated using live tracks of the Helios-1 spacecraft.

The last two tests were conducted between the STDN-Goldstone station and DSS 12 (Goldstone) on 17 and 25 June. Test results were very encouraging, demonstrating that it is possible to obtain 64 b/s coded telemetry from Helios 1 with a usable signal-to-noise ratio (SNR) (3 to 4 dB) at a 2-AU range from Earth.

A final report was assembled on the DSN-STDN engineering test results and forwarded to the U.S. Helios Project Manager. A decision is expected in September on whether to use the Goldstone STDN-DSN real-time microwave link configuration to support the Helios perihelion operations in October 1976.

D. Actual Tracking Coverage Versus Scheduled Coverage

This report covers tracking activities for a 63-day period from 7 June through 8 August 1976. Both Helios spacecraft were tracked a total of 123 times for a total of 801.8 hours. High Viking tracking requirements, plus Helios-2 solar occultation (spacecraft behind the Sun) accounted for the decrease in tracking hours from the last period. The Helios spacecraft received 47.8 percent of the DSN tracking time allotted to Pioneer and Helios after Viking requirements were satisfied. Helios 1 was tracked 82 times for a total of 576.6 hours. This represents a 21 percent decrease over the last report period. The average pass duration for Helios 1 was 7.03 hours compared to 7.6 hours for the last period. Helios 2 was tracked 41 times for a total of 225.2 hours with an average track time of 5.5 hours. Only 12.6 hours of 64-meter subnet support was allotted for Helios spacecraft during this period due to Viking requirements on the 64-meter subnet. Tracking coverage will remain sparse until completion of the Viking primary mission in November 1976.

III. DSN System Performance

A. Command System

Helios command activity dropped considerably during this report period to a total of 2910 commands as compared to 7331 commands for the last period. Two factors account for this decrease: (1) Helios tracking time was reduced to only 47 percent of that received during the last report period, and (2) Helios 2 spent most of this period in, or very near, solar occultation. DSN resources have been largely allocated to the support of the Viking mission. The cumulative command totals are now 39,248 for Helios 1 and 13,428 for Helios 2.

There were no command system aborts during the months of June and July 1976. The cumulative command system abort count remains at 10 for Helios 1 and 3 for Helios 2.

Total command system downtime for the months of June and July was 6 hours and 45 minutes. Although this figure is only one-third of the last report period, tracking time for these months was also much less. Of the 10 failures reported, 5 were associated with the loss of transmitters at DSS 44 (3 each) and DSS 12 (2 each).

B. Tracking System

The Helios-1 spacecraft's ranging transponder remained inoperative throughout this reporting period due to a temperature-dependent malfunction (Ref. 2). The ranging capability is not expected to return until after September. This fact, together with the concentrated attention being devoted to Helios-2's first superior conjunction, made for a low level of Helios-1 activity.

Helios 2 entered its first superior conjunction (SEP $\leq$ 5 degrees) on 4 May 1976 and will remain there through 6 October. During this time the spacecraft will have been occulted by the Sun three times. This period is of extreme importance to the Helios radio science team. Special "receiver ramping" procedures are still being conducted in support of this trajectory phase. Only preliminary results have been published thus far. Final results will require further analysis.

C. Telemetry System

Computer analysis of Helios-2 inferior conjunction data, collected in March–April 1976, is in progress. From these data, curve fits of SNR degradation as a function of the system noise temperature (SNT) are to be generated per spacecraft and tracking subnet (26 or 64 meters). The next logical step is the development of the superior conjunction model which will utilize the basic inferior conjunction model as well as additional modeling of the spectral broadening test data. It is planned that these models will improve DSN telemetry predicts, thus helping to determine best allocation of DSN resources during future superior conjunctions.

IV. Conclusions

With the Helios-1 spacecraft's ranging system already inoperative because of an onboard temperature problem, the spacecraft switched to the "safe mode" on 21 June 1976 because of a power overload. After a few anxious hours, the downlink was commanded *ON* and the spacecraft reconfigured for normal operation.

Helios 2, while in its first superior conjunction, has experienced two total solar occultations and will have one more before its second perihelion in mid-October.

The last two DSN-STDN engineering tests to prove the interstation microwave link configuration to support Helios were completed during this report period. A final encouraging report was sent to Project management.

Due to DSN resource commitments to Project Viking, Helios tracking time was reduced by over 50 percent during the last report period. The DSN system performance remained at a high level with no significant anomalies.

Data collected during Helios-2 inferior conjunction in March and April of 1976 are being analyzed and used to build a model for future superior conjunctions by the Network Operations Analysis Group.

Due to Viking-1 and -2 prime missions the Helios DSN tracking schedule is expected to remain at present levels, sharing equally the remaining tracking time with Pioneers 10 and 11.

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